III. REMARKS

1. Claims 1-20 and 22-47 are pending in the Application. Claims 19, 35, 41 and 43 are amended. Claims 1-18, 33, 34, 36 and 40 are cancelled without prejudice.

2. A new declaration identifying the citizenship of the inventors is being filed herewith.

3. An Affidavit (hereinafter the "Affidavit") under 37 C.F.R. 1.132 is being submitted herewith with respect to the cited references Amateau et al. (US 5,451,275, hereinafter "Amateau"), Cole (US 5,711,187) and Sonti et al. (US 6,779,270, hereinafter "Sonti").

4. It is respectfully submitted that the Examiner's assertion Applicant has argued against the references individually is incorrect. It is evident from Applicant's prior arguments as well as those included herein that the Applicant has clearly argued against the combination of the references.

5. Claims 19, 20 and 22-30 are patentable under 35 U.S.C. 103(a) over Amateau and Cole. Claim 19 calls for rolling the gear teeth surfaces of the powder metal workpiece to a substantially finished outer peripheral profiled shape. Claim 19 also calls for the gear teeth surfaces undergoing densification, plastic deformation, strengthening and final shaping as a result of the rolling operation. These features are not disclosed or suggested by the combination of Amateau and Cole.

As argued in Applicant's prior response, all that is disclosed in Amateau is that each rolling gear die (44, 46) has an outer peripheral profiled surface for rolling the gear teeth surfaces

of the workpiece (42) to a desired outer peripheral profiled shape (Col. 12, L. 64 - Col. 13, L. 2). The method and apparatus described in Amateau applies to wrought and/or forged steel gear wheels in which a previously carburized and hardened gear, hardened to over 60 HRC, is finished by thermal-mechanical means by inducing controlled plastic deformation in the metastable austenitic condition via gear rolling (See Affidavit at page 3, item 1). For wrought and/or forged gear wheels, the thermal-mechanical method of ausform gear roll finishing described in Amateau results in substantial material flow up and down the tooth surfaces and in the axial direction due to combined rolling and sliding action on the tooth surfaces, and unlike gear grinding, the outer most surface layers are not removed during ausform finishing operation, but instead are moved or smeared laterally on the tooth surface layers (See Affidavit at page 2, item 3). Thus, for gear wheels made of wrought and/or forged steels, the rolling dies for thermal-mechanical finishing are designed for combined rolling and sliding action on the tooth surface layers, wherein the material flow is laterally oriented in the tangential direction up and down the gear teeth as well as in the axial direction, but not in the radial direction as no radial compaction of the material is possible (See Affidavit at page 4, item 4).

Thus, Amateau does not disclose or suggest rolling the gear teeth surfaces of the powder metal workpiece to a substantially finished outer peripheral profiled shape as called for in Applicant's claim 19. Combining Amateau with Cole fails to remedy this defect.

Cole only discloses densification of the gear teeth by rolling (See e.g. Col. 1, L. 38-39; Col. 2, L. 42-45). There is

absolutely no disclosure in Cole of rolling the gear teeth surfaces of the workpiece "to a substantially finished outer peripheral profiled shape" as recited in Applicant's claims. The gears of Cole have to be case hardened by carburizing and hardening operations to achieve the specified surface hardness, hardness gradient and core strength necessary for high load bearing capability (See Affidavit at page 4, item 5). Case hardening heat treatment inherently results in substantial distortion of gear teeth, and therefore substantial loss results in accuracy and surface finish that was previously induced by the prefinishing method of Cole. Therefore, the sintered and densified PM gears in Cole require subsequent hard finishing by grinding, skiving, burnishing, or honing operations to achieve the level of accuracy and performance required for high performance power transmission gears. The grinding, skiving, burnishing, or honing operations result in removal of about 150 microns of the densified surface region of gear teeth. This removal of the surface layers of the gear teeth lowers the load bearing capacity because part of the surface region with densified surface layers, achieved using method as described in Cole patent followed by heat treatment, is removed, thus negating Cole's original densification intent (See Affidavit at pages 5-6, item 6(b)).

Thus, claim 19 is patentable over the combination of Amateau and Cole because the combination of Amateau and Cole does not disclose or suggest rolling the gear teeth surfaces of the powder metal workpiece to a substantially finished outer peripheral profiled shape. Claims 20 and 22-30 are patentable at least by reason of their respective dependencies.

Moreover, one skilled in the art would not merely apply the technique of Cole or substitute the elements of Cole into Amateau.

The processes of forming wrought steel gears and powder metal gears and the characteristics of wrought steel gears and powder metal gears are so different that one skilled in the art would not merely substitute the powder metal gear of Cole for the wrought steel gear of Amateau.

As noted above, Amateau is directed to metallurgically treating high performance steel gears by thermomechanical means to produce high strength and accurate contact surfaces using controlled deformation net shape finishing techniques (Col. 1, L. 11-15). The method described in Amateau applies only to wrought and/or forged steels, wherein material flow characteristics are such that only lateral flow occurs up and down the tooth surface and no radial compaction is possible. (See Affidavit at page 4, item 4). This is directly contrary to the forming of a powder metal gear wheel.

Cole discloses a powder metal gear wheel formed from a pressed and sintered powder metal blank where the surfaces of the gear teeth are hardened by densifying the tooth surface layers (Col. 1, L. 36-44). The gear wheels are produced in Cole using soft low carbon containing powder metal sintered steel containing substantial amount of porosity. The porosity found in powder metal gears is not present in wrought steel gears. The rolling dies used for finishing of sintered and case hardened powder metal gear wheels of Cole are required to be designed not to move or smear material laterally up and down the teeth, but instead are designed specifically to cause densification of surface layers involving substantial radial compaction of the material in

the tooth surface layers, thus resulting in the collapsing of the pores and densification of the gear surface. This is directly contrary to the rolling dies used for finishing the wrought and/or forged gear wheels of Amateau. (See Affidavit at page 6-9, item 6(d-e)).

Further, material flow properties and work hardening characteristics of high carbon metastable austenitic steel, as in Amateau, are inherently and substantially different from soft low carbon containing powder metal sintered ferritic/pearlitic steel such that the surface durability and bending fatigue of a powder metal gear does not meet the surface durability and bending fatigue performance of wrought steel gears (See Affidavit at page 7-10, item 6(g-h)).

The technique of Cole also would not merely be applied to Amateau as a ready improvement to Amateau for the reasons described above. In addition, the substantial differences between the production of powder metal gears and wrought steel gears as well as the characteristics of each, as described above, in effect teach away from combining the references.

For example, the formation of gear wheels from wrought or forged steel involves plastic deformation of gear tooth surface layers, resulting in smearing of material over the tooth surfaces. Plastic deformation of wrought or forged material involves permanent plastic flow, but with zero volume change. Plastic deformation depends on the flow stress (e.g. yield stress in uniaxial loading) of the material as well as formability (ability to deform without failure). Flow stress is influenced by material composition and related microstructural features, as well as strain, strain rate and temperature. In contrast, surface densification of conventional powder metal gears as

described in Cole involves substantial volume change due to collapsing of pores. Compressibility of the material plays the most significant role, which is influenced by porosity amount and distribution, as well as material composition, prior strain and/or heat treatment history. In the case of Cole, the primary factors are therefore porosity and steel composition/phase.

Constitutive relations or plastic flow rules that are applicable for constant volume plastic deformation of wrought or forged steels are either Tresca's maximum shear stress criteria for yield, or Von Mises minimum distortion energy criteria for yield. These are not applicable for surface densification of soft powder metal steel gears via compaction, as these materials are compressible due to the inherent pores and therefore volume is not constant.

For plastic deformation of wrought or forged material below the steel recrystallization temperature (defined as cold forming), strain rate effects are generally not significant, whereas strain effects (i.e. strain or work hardening) are quite significant. That is, after some plastic flow, additional flow requires increasingly higher stresses. On the other hand, surface densification of powder metal gears as described in Cole, is applicable to powder metal compositions with low carbon content of 0.2% or less, and is carried out at room temperature. The gear of Cole in the as pressed and sintered condition prior to surface densification is soft, consisting entirely of ferritic/pearlitic phase, with apparent hardness of 180-200 BHN. As surface densification described in Cole only involves compaction of soft surface layers, work hardening effects are not significant.

Further, mechanical properties (modulus of elasticity, yield strength, fatigue strength, etc.) for soft powder metal steels in pearlitic/ferritic condition are primarily a function of material composition and porosity in both amount and distribution. Strain and strain rate effects are negligible. Contact pressure and width, which a function of the modulus and yield strength, are therefore affected primarily by the degree of porosity. In contrast, mechanical properties for hardened powder metal steels are not only a function of material composition and porosity, but also the metallurgical phase (tempered martensite or metastable austenite), and the respective work hardening characteristics. Contact pressure and width are therefore affected by the work hardening characteristics of metastable austenite, and the underlying mixture of metastable austenite and hardened tempered martensite, as well as by the degree of porosity. (Affidavit, page 10-11, item 8).

Moreover, the Amateau reference was issued about twelve years ago on September 19, 1995. The Cole reference was issued about nine years ago on January 27, 1998. These references have coexisted for about nine years. If it were so obvious to one skilled in the art to apply Cole to Amateau as the Examiner suggests these references would have been combined long ago in light of the numerous other attempts, as described in various other patents and publications, to increase the surface durability of the powder metal gears. This alone is substantial evidence that one skilled in the art would not merely substitute or apply Cole to Amateau.

Further, it is noted that in contrast to the method described in Cole, the method described in the current application results in finished powder metal gear wheels with high hardness, strength,

accuracy and surface finish that do not require any further post hardening operations. It is to be noted that performance of gear wheels in surface durability fatigue tests have shown that powder metal gear wheels produced by the method described in the present application have been demonstrated to not only equal but surpass the surface durability performance of current wrought steel gears. (See Affidavit at page 7-8, item 7).

6. Claim 47 is patentable under 35 U.S.C. 103(a) over Amateau and Cole. Claim 47 depends from claim 19. For the reasons described above, the combination of Amateau and Cole does not disclose or suggest all the features of claim 19. Thus, claim 47 is patentable at least by reason of its dependency.

Furthermore, claim 47 recites that the root/fillet region of the gear teeth are compacted with a rolling die having a tip radius from about 0.014 to about 0.018 inches. The Examiner notes that the combination of Amateau and Cole does not disclose this feature. It is submitted that one skilled in the art would not be motivated to modify the rolling die of Amateau in view of Cole for reasons that are substantially similar to those described above with respect to claim 19. In addition, because neither Amateau nor Cole disclose or suggest a rolling die having a tip radius from about 0.014 to about 0.018 inches, their combination can not reasonably suggest the specific range recited by Applicant as asserted by the Examiner. Thus, claim 47 is patentable.

7. Claims 31 and 32 are patentable under 35 U.S.C. 103(a) over Amateau and Cole in further view of Torii et al. (US 4,972,735, hereinafter "Torii"). Claims 31 and 32 depend from claim 19. For the reasons described above, the combination of Amateau and Cole does not disclose or suggest all the features of claim 19.

It is submitted that because the combination of Amateau and Cole does not disclose or suggest all the features of claim 19 the combination of Amateau, Cole and Torii can not as well. Therefore, claims 31 and 32 are patentable at least by reason of their respective dependencies.

Furthermore, Torii merely discloses a wrist assembly for an industrial robot and is in no way concerned with manufacturing techniques of gears.

It is submitted that Torii is non-analogous art. References may be combined under 35 U.S.C. 103(a) only if the references are analogous art. A reference is analogous art if:

1) The reference is in the same field of endeavor as the applicant's; or

2) The reference is reasonably pertinent to the particular problem with which the applicant was concerned.

Torii is not in the same field as the Applicant's. Torii is solely concerned with industrial robots and in particular the wrist assembly of an industrial robot (See e.g. Abstract).

Torii is not reasonably pertinent to the particular problem with which the applicant was concerned. As described above Torii is only concerned with industrial robots. The mere recitation of a certain type of gear used in the wrist assembly in Torii (e.g. Col. 4, L. 8-29) can hardly be construed as making Torii pertinent to gear manufacturing.

Since Torii is not in the same field of endeavor and is not reasonably pertinent to the particular problem with which

Applicant was concerned, Torii is not analogous art. Therefore, Torii may not be properly combined with Amateau and Cole.

Thus, claims 31 and 32 are patentable for these additional reasons.

8. Claims 35, 37-39 and 41-46 are patentable under 35 U.S.C. 103(a) over Sonti and Cole. Claim 35 calls for rolling the gear teeth surfaces of the powder metal workpiece to a substantially finished outer peripheral profiled shape. This feature is not disclosed or suggested by the combination of Sonti and Cole.

Sonti discloses that hobbed gear tooth profiles are produced for subsequent full form finishing (Col. 5, L. 2-4). The method described in Sonti is applicable to only gear wheels produced using wrought and/or forged steels as the plastic deformation induced in the surface layers is such that only lateral material flow occurs up and down the tooth surface layers. Nowhere does Sonti disclose or suggest rolling the gear teeth surfaces of a powder metal workpiece to a substantially finished outer peripheral profiled shape. (See Affidavit at pages 3-4, items 2-4). Combining Sonti with Cole fails to remedy this defect.

As described above, Cole only discloses densification of the gear teeth by rolling (See e.g. Col. 1, L. 38-39; Col. 2, L. 42-45). There is absolutely no disclosure in Cole of rolling the gear teeth surfaces of the workpiece "to a substantially finished outer peripheral profiled shape" as recited in Applicant's claims. The gears of Cole have to be case hardened by carburizing and hardening operations to achieve the specified surface hardness, hardness gradient and core strength necessary for high load bearing capability (See Affidavit at page 4, item 5). Case hardening heat treatment inherently results in

substantial distortion of gear teeth, and therefore substantial loss results in accuracy and surface finish that was previously induced by the prefinishing method of Cole. Therefore, the sintered and densified PM gears in Cole require subsequent hard finishing by grinding, skiving, burnishing, or honing operations to achieve the level of accuracy and performance required for high performance power transmission gears. The grinding, skiving, burnishing, or honing operations result in removal of about 150 microns of the densified surface region of gear teeth. This removal of the surface layers of the gear teeth lowers the load bearing capacity because part of the surface region with densified surface layers, achieved using method as described in Cole patent followed by heat treatment, is removed, thus negating Cole's original densification intent (See Affidavit at pages 4-6, item 6(b)).

Thus, claim 35 is patentable over the combination of Sonti and Cole at least for the reason that their combination does not disclose or suggest rolling the gear teeth surfaces of a powder metal workpiece to a substantially finished outer peripheral profiled shape as recite in claim 35. Claims 41 and 43 are patentable over the combination of Sonti and Cole for reasons that are substantially similar to those described above with respect to claim 35. Claims 37-39, 42 and 44-46 are patentable at least by reason of their respective dependencies.

It is further submitted that one skilled in the art would not combine Cole with Sonti as a mere substitution of one known element for another or the mere application of a known technique to a piece of prior art ready for improvement for reasons that are substantially similar to those described above with respect to claim 19.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record, and are in proper form for allowance. Accordingly, favorable reconsideration and allowance is respectfully requested. Should any unresolved issues remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

The Commissioner is hereby authorized to charge payment for one additional dependent claim and any fees associated with this communication or credit any over payment to Deposit Account No. 16-1350.

Respectfully submitted,

9-10-2007

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